NFPA Fluid Power VEHICLE Challenge

NFPA Education and Technology Foundation

University of CINCINNATI

FINAL PRESENTATION
UNIVERSITY OF CINCINNATI
MUTHAR AL-UBAIDI
APRIL 8TH 2021

Agenda

- Team Introductions
- Problem Statement & Objectives
- Summary of Midway Presentation
- Vehicle construction
- Progress Made Towards Final Vehicle
- Lessons Learned
- Questions

Team Introductions

Muthar Al-Ubaidi, PhD

- **Professor and Director Mechanical Engineering Technology Program**
- **Education**
  - B.S. Mechanical Engineering, University of Baghdad
  - Masters Nuclear Engineering, University of London
  - PhD Nuclear Engineering, University of Cincinnati
- **Hometown**
  - Baghdad, Iraq
  - Came to Cincinnati, USA in 1978
- **Project Team**
  - Faculty Advisor

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Jake Fitzsimmons

- **Major**
  - B.S. Mechanical Engineering Technology
- **Year**
  - 5th
- **Hometown**
  - Springfield, Ohio
- **After Graduation**
  - Process Engineer at SugarCreek
- **Project Team**
  - Frame Team & Team Lead

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Molly Hoying

- **Major**
  - B.S. Mechanical Engineering Technology
  - Master, Business Administration
- **Year**
  - 5th
- **Hometown**
  - Centerville, Ohio
- **After Graduation**
  - Data Analyst at L3Harris
- **Project Team**
  - Circuit Team

Chris Schalk

- **Major**
  - B.S. Mechanical Engineering Technology
- **Year**
  - 5th
- **Hometown**
  - Loveland, Ohio
- **Co-op Experiences**
  - KBA Architects
  - TECT Power
  - Cincinnati Incorporated
- **Project Team**
  - Frame & Gearing Team

Ian Gilbertsen

- **Major**
  - B.S. Mechanical Engineering Technology
- **Year**
  - 4th
- **Hometown**
  - Powell, Ohio
- **Co-op Experiences**
  - GE Appliances, a Haier Company
  - Goodyear Tire and Rubber Company
- **Project Team**
  - Circuit Team

Christopher Pyzik

- **Major**
  - B.S. Mechanical Engineering Technology
- **Year**
  - 5th
- **Hometown**
  - Avon Lake, Ohio
- **After Graduation**
  - Project Engineer at Emerson Electric
- **Project Team**
  - PLC Design & Circuit Team

Assigned Mentor

Assigned Mentor

- Dan Turner of GPM Controls
  - Hydraulic expert.
  - Provided oversight on manifold, circuit, and calculations.
  - Supplied necessary connections for build.

GPM Controls

Don't just go with the flow... Control it!

Problem Statement & Objectives

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Norgren Competition

Problem Statement & Objectives

- Achieve a 15-mph max speed
- Increase the efficiency of the bike
- Use only 5% from last year's bike
- Improve on last year's design

Circuit and Vehicle Design

- Enhanced circuit design and features
- Improve component placement
- Improve frame design
- Implementing a pneumatic component

Overall

- Master new concepts
- Work ahead and prepare

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Summary of Midway Presentation

Summary of Midway Presentation

Design Objectives:

- Decrease the overall height of the bike from last year's design to make it easier to ride.
- Create a "cleaner" circuit with a custom manifold.
- Increase the overall efficiency of the bike compared to last year.
- Decrease the overall weight for greater efficiency and speed.
- Improve the PLC design.

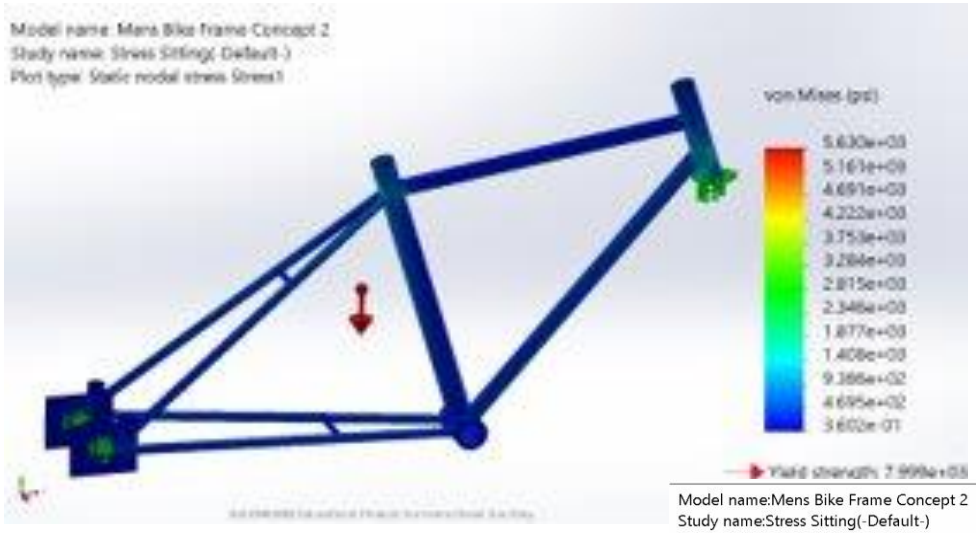
Summary of Midway Presentation

Vehicle design:

- Standard men's design based on its geometry to store reservoir
- Ensures accumulator is upright
- Created manifold to reduce weight and complexity
- Picked a steel frame material based on its manufacturability

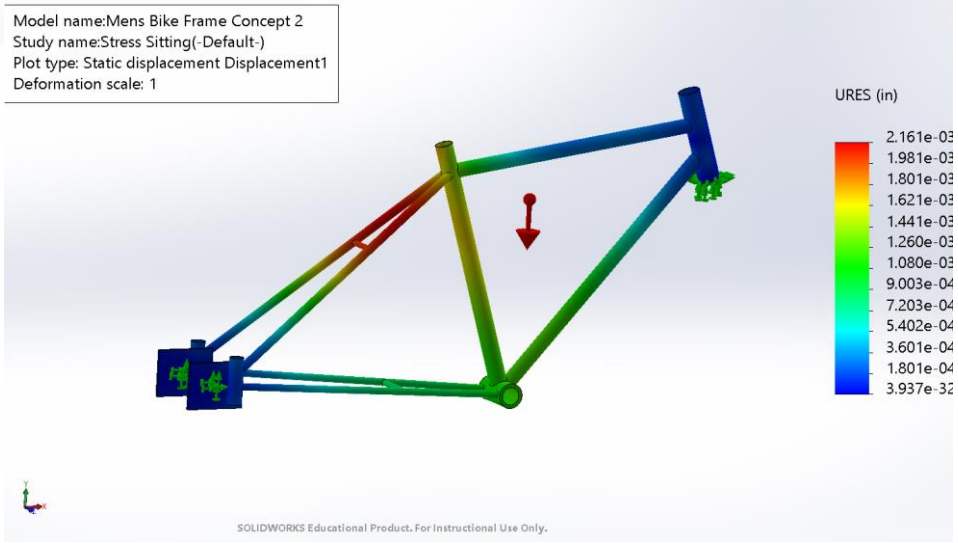
Solidworks Assembly (Right Side)

Summary of Midway Presentation



Men's Bike Frame FEA Static Stress Plot

Men's Bike Frame FEA Displacement Plot



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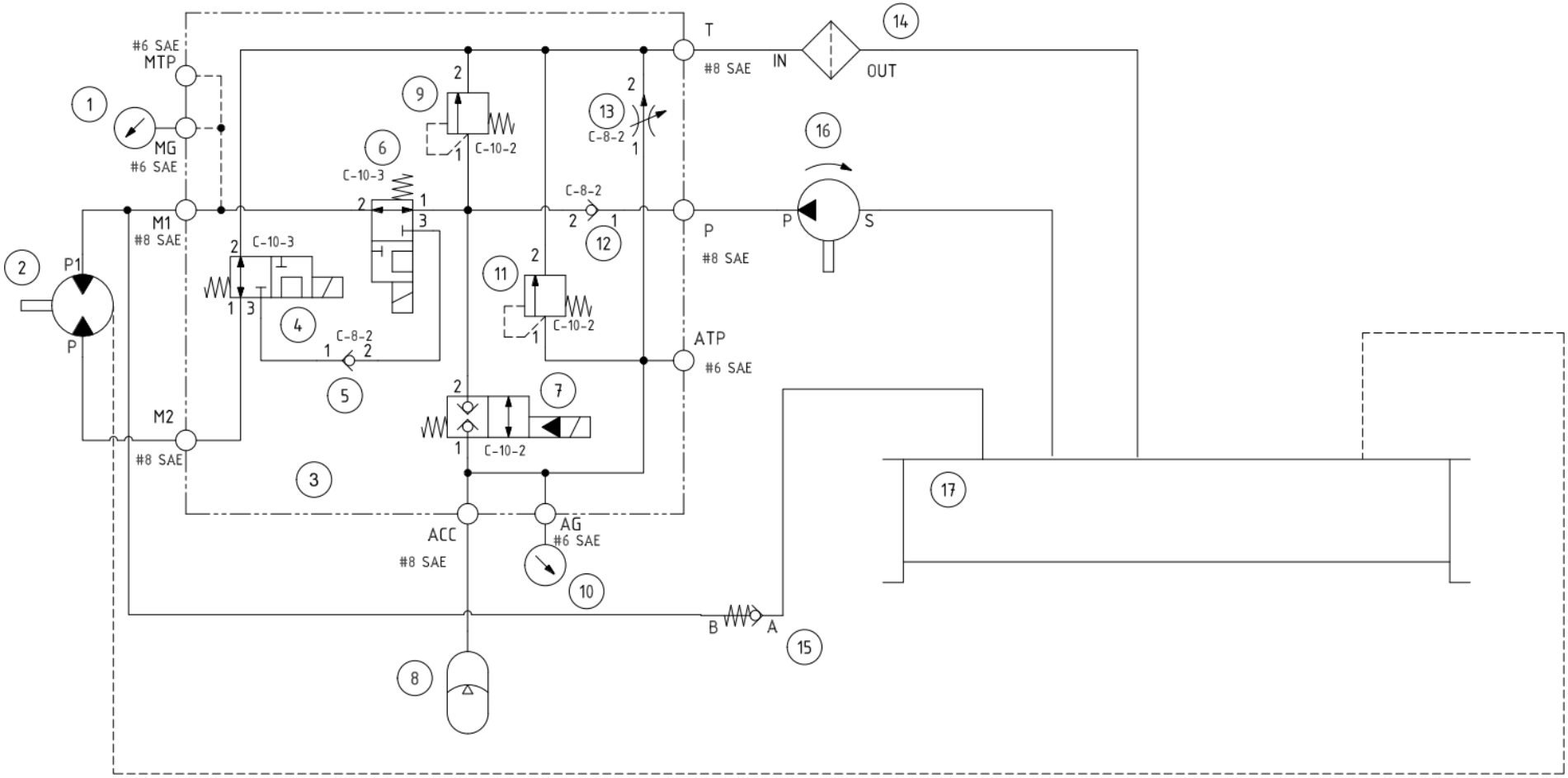
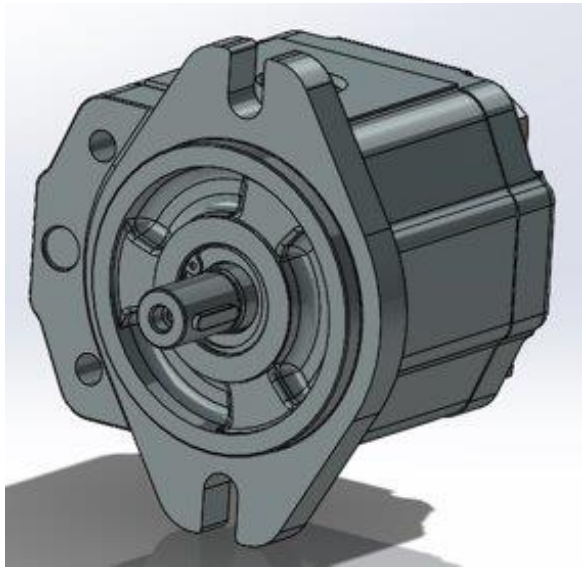
Fluid Power Circuit Design:



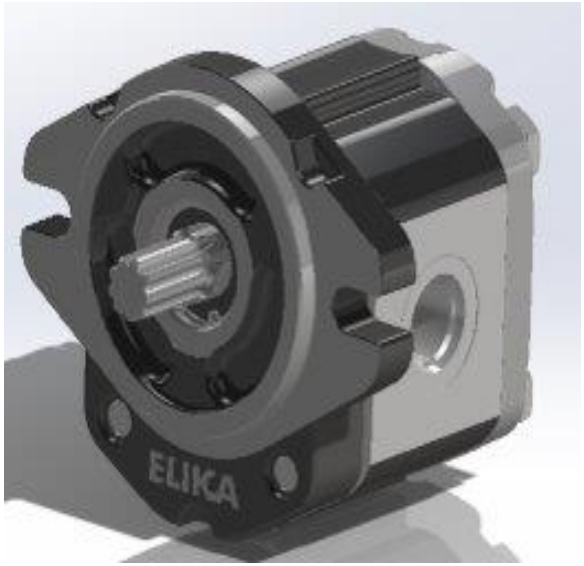
Summary of Midway Presentation

Selection of Hardware:



Motor: Danfoss SNM2NN

- .513 CIR
- Chosen based off calculations.



Pump: Elika ELI2A-D-9.6

- .586 CIR
- More efficient at low rpm due to helical gears.

Accumulator: Carbon Fiber

- 1 Gallon Bladder
- 3000 psi
- Very lightweight (10.8lbs)

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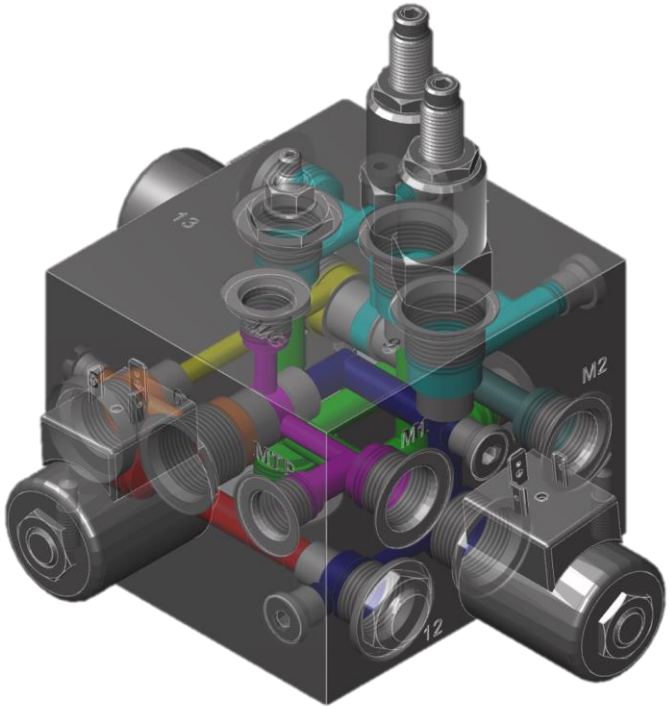
Custom Hydraulic Manifold:

- Utilized VEST Inc. for manifold design software and training.



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Summary of Midway Presentation

Electronic Hardware:

PLC: Barth STG-600

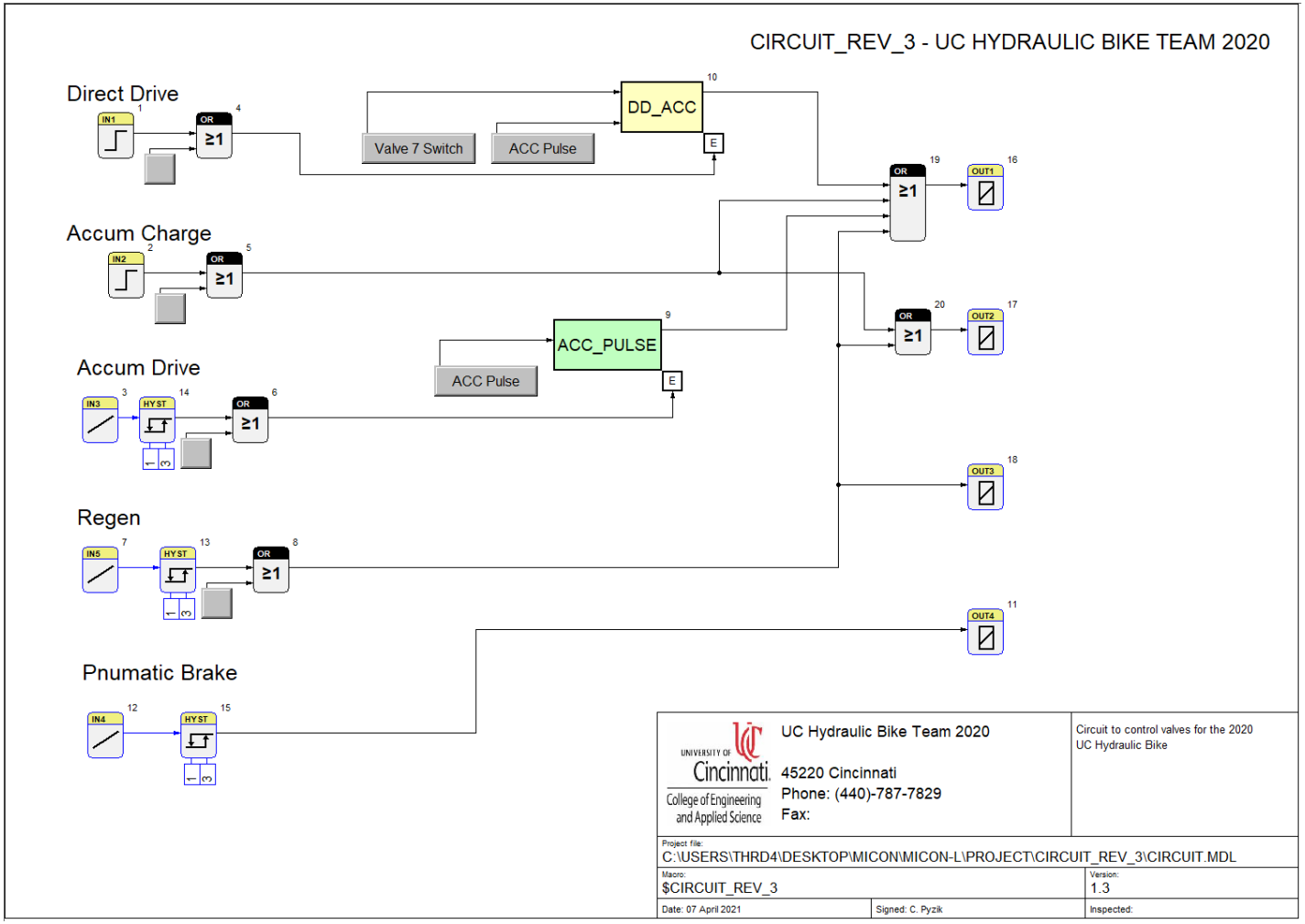
- 10 Inputs – 9 Outputs
- Wide range of voltages
- Intuitive programming software

PLC Extras: Arduino & LCD

- Arduino Uno
- I^2C LCD
- Displays drive modes to user

Summary of Midway Presentation

PLC Program:



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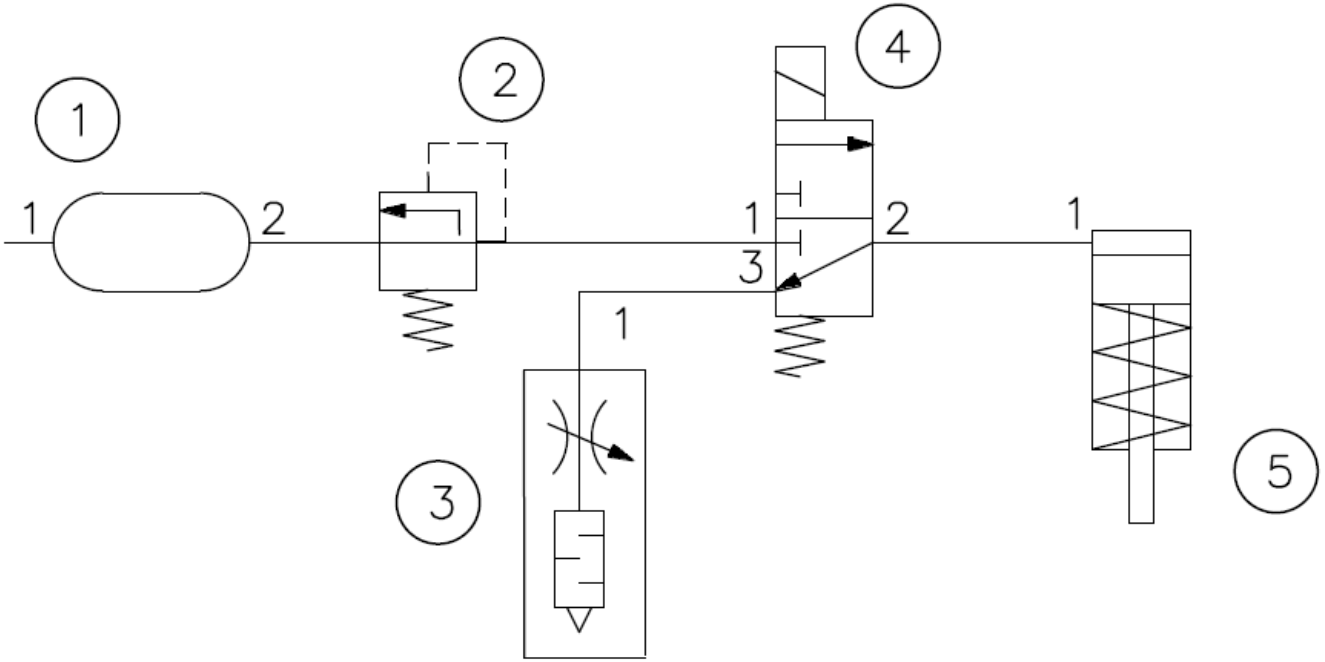
Pneumatic Brake Design:



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Selection of Hardware:

Pneumatic Receiver:

- 2"x12"
- 250 Max PSI

Air Cylinder:

- Retracts when pressure is provided
- 250 Max PSI

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Race Results

Sprint Race	
1	00:52.44
2	01:07.81

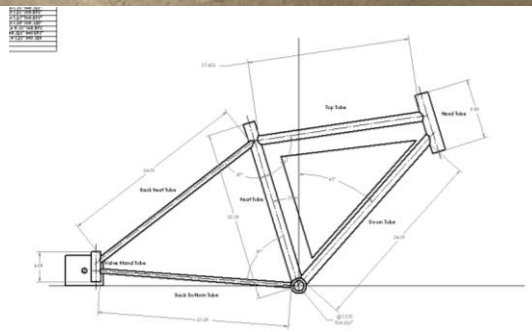
Endurance Race	
1	10:09.87
2	N/A

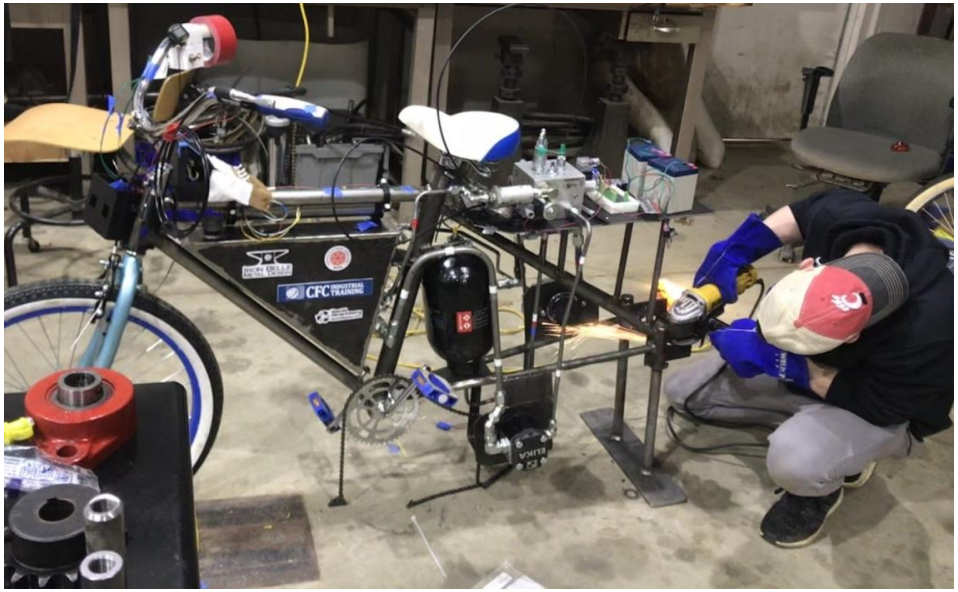
Efficiency Race	
1	24.35 (100') 2:44.92 (1136.50')
2	20.42 (100') 2:18.34 (1193.00')

Vehicle Construction

Vehicle Construction

Frame Build:



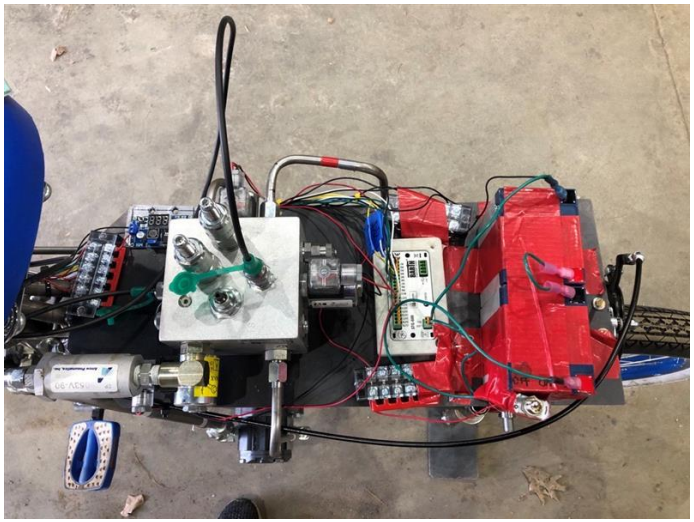


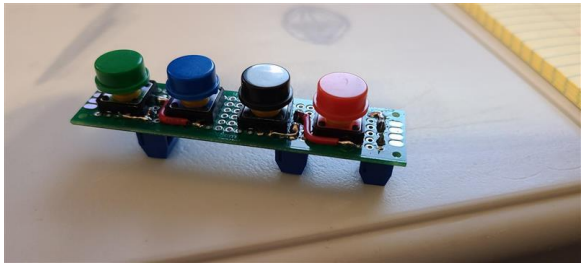
Vehicle Construction

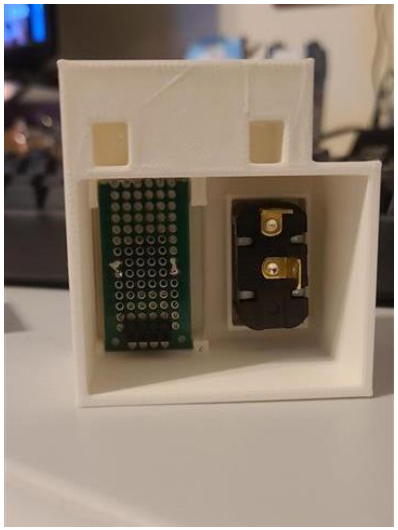
Hydraulic Circuit & Piping Build:

Vehicle Construction

Electronics:

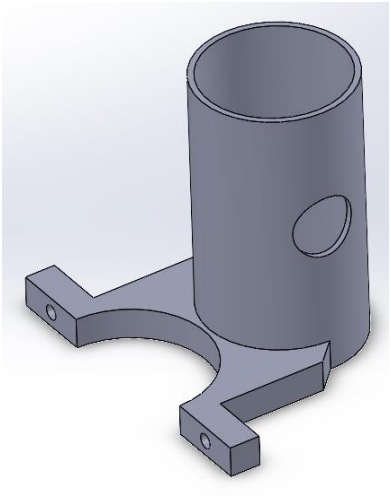


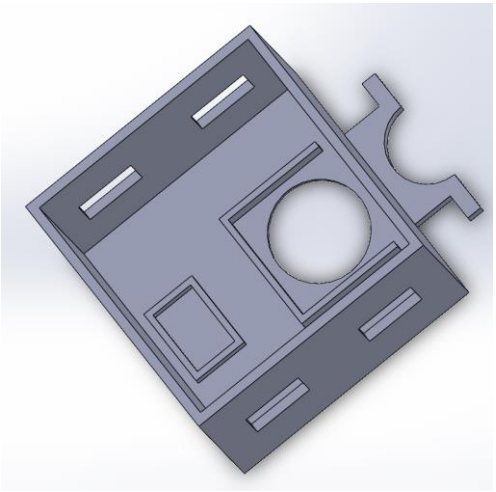


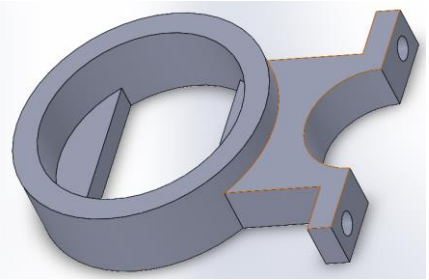


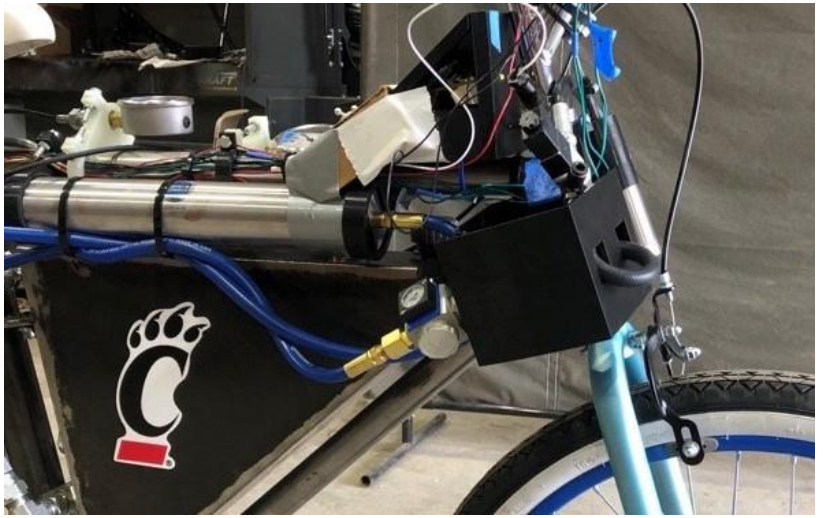
Vehicle Construction

Pneumatic Circuit Build:









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Progress Made Towards Final Vehicle

Progress Made Towards Final Vehicle

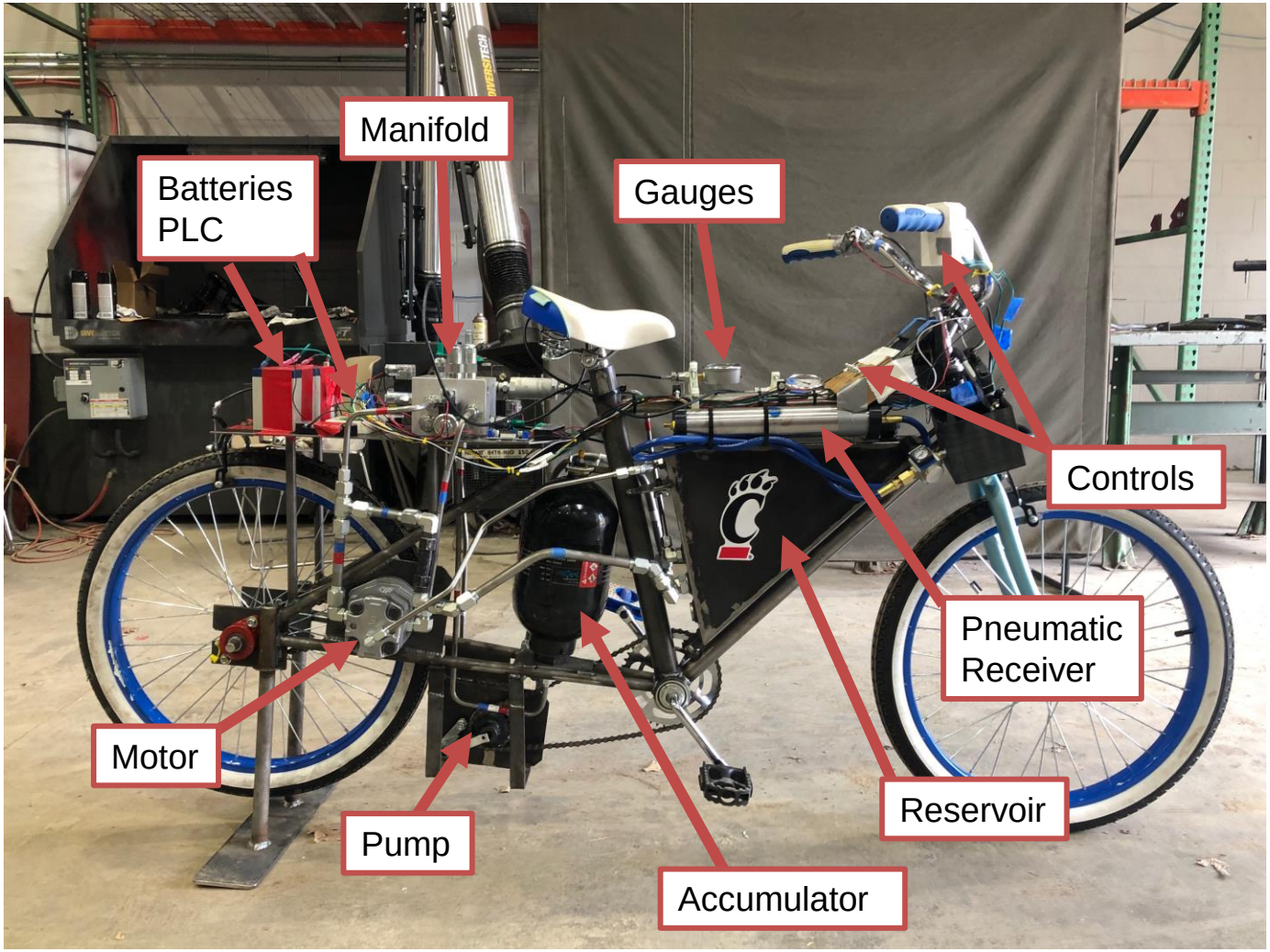
Reliability: Test runs of drive modes, tested by several people, robust and durable but not heavy.

Safety: Pneumatic Brake, Accessibility of Buttons, Chains on interior of frame, Comfortable.

Quality: Hand built the circuit tubing, 3D printed components attached externally, Original design.

Final Vehicle

Final Vehicle Components



Lessons learned

Lessons Learned

Design:

- Chain length was slightly off in placement with petals and pump.
- Incorrectly sized port for reservoir
- Allocate more time for the testing of the bike
- Add stronger check valve after pump.
- Design a gear ratio between motor and drive wheel for regen circuit.

Build:

- Pump/motor placement had to be altered for the chain
- Order extra parts in case any components break. (i.e. PLC and Voltage Reducer)
- Needed bearings for back wheel
- Need more clearance for back wheel and frame

Thank You!

Questions?